Propensity-matched analysis of outcomes after mitral valve surgery between trainees and consultants (institutional report)

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Abstract

OBJECTIVES

We aimed to determine whether early outcomes and long-term survival after mitral valve surgery performed by trainee residents are equivalent in terms of safety and efficacy when compared with consultant surgeons.

METHODS

Between January 2000 and December 2015, a total of 1742 patients who underwent mitral valve surgery were identified. Of these, 1622 operations were performed by consultants (Group I) and 120 operations were performed by trainees (Group II). A propensity score-matched analysis has been used to minimize selection bias. Early postoperative outcomes were defined as in-hospital mortality, cerebrovascular accident, postoperative requirement of renal replacement therapy, reoperation for bleeding and postoperative length of hospital stay. Long-term outcomes were evaluated using late survival data after discharge.

RESULTS

Before matching, the 2 groups differed significantly in terms of gender and reduced left ventricular ejection fraction, but these differences were solved after matching. Also, Group I included significantly more patients with mitral regurgitation (83% vs 62%; $P < 0.01$), but after matching, this difference was corrected (62% vs 59%; $P = 0.71$). Consultant group was associated with a higher in-hospital mortality (6% vs 2%; $P = 0.04$) in the unmatched population. Moreover, in the unmatched cohort, this group had longer cross-clamp time compared with the trainees group (91 ± 38 vs 89 ± 26 min; $P = 0.47$) and longer cardiopulmonary bypass time (132 ± 58 vs 121 ± 33 min; $P = 0.27$); these differences were not statistically significant. There were no significant differences in postoperative dialysis, cerebrovascular accident, reoperation for bleeding and length of hospital stay. Even after matching, no significant differences were found in terms of perioperative complications. The Kaplan–Meier survival curves at 1, 5 and 10 years were similar between the 2 groups.

CONCLUSIONS

Mitral valve surgery can be safely performed by trainees and provides similar short- and long-term results compared with consultant surgeons.

INTRODUCTION

Mitral valve (MV) surgery is the recommended intervention in patients who have severe mitral regurgitation (MR) or mitral stenosis with signs and/or symptoms despite optimal therapy [1–3]. The Framingham study showed an estimated 2–3% prevalence of MV prolapse, a proportion of which will progress to severe MR requiring surgical intervention [4]. Keeping in mind this high burden of disease, it is imperative that the future cardiac surgeons are adequately trained in MV surgery. Nevertheless, concerns have been raised about the safety of training surgeons in the performance of complex cardiac procedures, particularly MV repair [5]. Surgical training requires a precarious balance between the standard of care delivered to patients and provision of sufficient operative exposure to trainees who are the cardiac surgeons of the future. The balancing act is, therefore, to maintain excellent clinical outcomes and at the same time delivering the responsibility of teaching and developing skills in junior surgeon [6–8]. Additionally, there is a well-established correlation between caseload and outcomes after MV surgery for individual surgeons [9]. In light of enhanced efforts to scrutinize and improve patient outcomes, there may be a resultant loss of direct surgical experience for surgeons-in-training [10, 11].

We sought to determine whether MV surgery performed by trainee residents is equivalent in terms of safety and quality when compared with consultants.

MATERIALS AND METHODS

Study design

We carried out a retrospective analysis of prospectively collected data on consecutive patients who underwent MV surgery in our institution between January 2000 and December 2015. The study was conducted in accordance with the principles of the Declaration of Helsinki. The local audit committee approved the study, and the requirement for individual patient consent was waived.

A total of 1742 patients were identified. Of these, 1622 operations were performed by consultants [MV replacement (n = 856) and MV repairs (n = 764)]. During the same period of time, trainees performed 73 MV replacements and 47 MV repairs as first operator.

All the operations performed by trainees were directly supervised by the responsible consultant who was scrubbed on the table as first assistant.

Preoperative, operative and postoperative data were obtained from patient records and institutional database. The preoperative characteristics are listed in Table 1. Intraoperative data included type of MV procedure, concomitant procedures, cardiopulmonary bypass time and aortic cross-clamp time.

Data are expressed as median (IQR) for numerical variables and as n (%) for categorical variables.

AF: atrial fibrillation; BMI: body mass index; CCS: Canadian Cardiovascular Society; IQR: interquartile range; LVEF: left ventricular ejection fraction; MI: myocardial infarction; MV: mitral valve; NYHA: New York Heart Association; PCI: percutaneous coronary intervention; SMD: standardized mean difference.

Outcomes

Early postoperative outcomes were defined as in-hospital mortality, cerebrovascular accident, postoperative requirement of renal replacement therapy, reoperation for bleeding and postoperative length of hospital stay. Long-term outcomes were evaluated using late survival data after discharge.

Statistical analysis

Statistical analysis was conducted using R version 3.0.2 (R Foundation for Statistical Computing, Vienna, Austria). Data were checked for normality using ‘Shapiro–Wilk test’. Continuous variables were presented as median and interquartile range, whereas categorical variables as absolute numbers and percentages. The 2 groups were compared using the Mann–Whitney U-test, while categorical variables were compared with the $\chi 2$ test or the Fisher's exact test as appropriate.

Bias regarding allocation of cases to trainees was corrected using a propensity score (PS)-matched analysis. A PS was generated for each patient based on the subsequent variables: age, gender, reduced left ventricular ejection fraction (LVEF), previous myocardial infarction, EuroSCORE, presence of atrial fibrillation, New York Heart Association class, previous surgical procedures, type of MV disease, aetiology of the disease and urgency level. The method used was greedy matching with a caliper of 0.2. Patients in both groups were one-to-one matched based on their PS. As a result, 2 paired groups with 120 patients in each group were obtained. These 2 groups were compared using paired Wilcoxon signed-rank test, with continuity correction for continuous variables and exact McNemar's test for categorical variables.

Survival rates were estimated using the Kaplan–Meier method and log-rank test. All tests were 2 tailed and alpha error was set at 0.05.

RESULTS

Unmatched analysis

Table 1 lists the preoperative characteristics of the patients: the left side of the table shows the unmatched analysis. In the unmatched cohort, the overall mean age was of 65.9 ± 13 years. Trainee group included a greater proportion of female patients (55% vs 38%; $P < 0.01$). There was a significantly higher proportion of patients with impaired LVEF in Consultant group (34% vs 18%; $P < 0.01$). This group also included more patients with MR (83% vs 62%; $P < 0.01$). In this cohort of patients, consultant group had a larger number of patients with endocarditis (10% vs 4%) and ischaemic MV disease (9% vs 4%), while trainee group had a larger number of rheumatic disease (37% vs 14%, $P < 0.01$).

Intraoperative and postoperative outcomes are listed in Table 2. In the unmatched analysis, the incidence of concomitant procedures was higher for consultants (29% vs 23%, respectively; $P < 0.01$). Consultant group was also presenting a higher in-hospital mortality (6% vs 2%; $P = 0.04$) in the unmatched population, while no difference was found in terms of dialysis (4% vs 1%; P = 0.18), cerebrovascular accidents (2% vs 1%; P = 1), reoperation for bleeding (6% vs 5%; P = 1) and hospital length of stay (11.9 ± 10.7 days vs 12.5 ± 10.7 days; P = 0.43).Survival data were available for 1552 patients in the overall cohort (89.1%). Figure 1 shows the Kaplan–Meier survival curves of the 2 groups. At 1 year, the survival was 90.3 ± 7.9% vs 95.6 ± 1.9%; at 5 years, 77.5 ± 1.3% vs 84.1 ± 3.6% and at 10 years, 59.6 ± 2.2% vs 61.1 ± 7.1%, for consultant versus trainee, respectively (log-rank test P = 0.35).

Matched analysis

The preoperative characteristics were similar after PS matching (Table 1): particularly female gender (59% vs 55%, P = 0.58) and reduced LVEF (19% vs 18%, P = 1) were similar. There were no differences in terms of postoperative outcomes (Table 2): in-hospital mortality was 6% in consultant group vs 2% in trainee group (P = 0.18); postoperative dialysis was required in 4% vs 1% (P = 0.10); cerebrovascular accident rates were 2% vs 2% (P = 1) and reopening for bleeding was required in 4% vs 6% (P = 0.77). Length of stay was also similar: 10.9 ± 7.1 days in consultant vs 11.8 ± 10.7 days in trainee (P = 0.61).

Figure 2 shows the Kaplan–Meier survival curves of the 2 groups after matching. At 1 year, the survival was 91.6 ± 2.6 vs 95.6 ± 1.9%; at 5 years, 76.4 ± 4.8% vs 84.1 ± 3.6% and at 10 years, 57.9 ± 7.3% vs 61.1 ± 7.1%, for consultant and trainee, respectively (log-rank test P = 0.29).

Figure 2:

The Kaplan–Meier survival for patients undergoing mitral valve surgery after propensity match.

The Kaplan–Meier survival for patients undergoing mitral valve surgery after propensity match.

DISCUSSION

Senior cardiac surgeons are fully aware of the importance of training the next generation of surgeons, but, at the same time, they have an over-riding responsibility to ensure patient safety and good clinical outcomes. As already stated by Alexiou et al. [8], in the UK, the consultant trainers are under considerable pressure generated by the growing demands for improved clinical results, while operating on higher risk patients, and the intense public scrutiny of their clinical performance. More recently, the European Working Time Directive (EWTD) has further shortened the time that a trainee can dedicate to active training in hospital. There are concerns that these factors may adversely affect the quality of education and the hands-on experience provided to cardiothoracic surgery trainees. In our institution, we have previously demonstrated that it is possible to train residents in complex cardiac procedures and increase trainee exposure to new techniques like off-pump coronary surgery without compromising the patient safety and the early and long-term outcomes [12, 13].

The main finding of this study is that training residents in performing MV surgery is safe and reproducible without leading to unexpected complications. Our data indicate that residents as primary operators during complex MV procedures are not associated with adverse patient outcomes and surgery performed by a trainee does not represent a factor that increase the postoperative mortality rate. In this study, we found that overall (in the real world), compared to trainees performing mitral surgery, consultants were more likely to operate on women, those with reduced LVEF and with MR. This is not unexpected as cases with higher degree of complexity are generally assigned to consultant and are more likely to be unsuitable for training purposes. After matching the 2 groups, trainees were more likely to perform a significant proportion of MV repairs. This seems intuitive as, with the matching process, it is possible that the higher risk cases performed by consultants were dropped and the new consultant group had a lower risk profile hence representing a more suitable group for repair. It is also not surprising to find in this study that in the unmatched population, there was a higher in-hospital mortality and new dialysis incidence in the consultant group due to the higher risk profile of these patients. This difference was not seen after matching.

An interesting finding from our study is that after application of PS, consultants tend to have longer cross-clamp times. Conversely, it has been reported in the literature that trainees tend to have longer cross-clamp time and cardiopulmonary bypass time times. Shi et al. [5] found that consultants had significantly shorter cross-clamp times compared with trainees. This has also been seen by Murzi et al. [6] in a study that focused on training in minimally invasive mitral surgery. Another study published by Baskett et al. [7] did not show significant difference in the cross-clamp times between consultants and trainees. Our finding may be related to the higher number of concomitant procedures performed by consultants. Although not reaching statistical significance, this was the case after matching, supported by the fact that the difference in cross-clamp time did not translate into a longer cardiopulmonary bypass time. Although cross-clamp and cardiopulmonary bypass times were reported as independent predictors of mortality and morbidity [14, 15], we did not see any statistically significant difference in these variables. Other reports in literature corroborate our results, showing that the relation between aortic cross-clamp time and mortality is not as straightforward as expected and underlying the concept of meticulous myocardial protection to prevent damage in operations with expected longer cross-clamp time [16–18].

Differences in the cross-clamp times in different series could be a result of unexpected anatomy, surgical complexity and surgical expertise in other reported studies. Even with the use of PS analysis, these characteristics can be particularly difficult to quantify. It is highly likely that in our study, the shorter cross-clamp time in the trainee group is due to appropriately selected cases, which were technically easier in terms of anatomy and the actual procedure.

Limitations

This study has some limitations. It is a retrospective analysis, hence an attempt has been made to eliminate this bias with PS matching. Intraoperative data with regard to valve lesion's type (posterior vs anterior) and repair techniques are not available. This makes it difficult to comment on the degree of complexity of the surgery, but it is very likely that the operations performed by trainees were the simpler ones (annuloplasty, leaflet resection, neochordae insertion and valve replacement). Postoperative long-term echo data are not available, and hence no comment can be made on the durability of repair. However, it is reassuring to see that the quality of training is imparted to the trainees in a manner which is safe and reproducible and the long-term survival is not compromised.

CONCLUSION

In conclusion, our analysis shows that trainees as primary operators for appropriately selected patients undergoing MV surgery do not impact on the early postoperative outcomes and long-term survival rates.

Conflict of interest: none declared.

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Table 1. Preoperative and intraoperative characteristics of patients

Characteristics	Unmatched analysis				Matched analysis			
	Trainees (*n* = 120)	Consultants (*n* = 1622)	*P*-value	SMD	Trainees (*n* = 120)	Consultants (*n* = 120)	*P*-value	SMD
Age (years)	69.1 (59.3–75.2)	68.3 (59.9–75.2)	0.45	0.11	69.1 (59.3–76)	67.4 (58.4–73.6)	0.15	0.18
Female gender	66 (55)	622 (38)	<0.01	0.33	66 (55)	71 (59)	0.58	0.08
BMI (kg/m^2)	24.8 (22.3–27)	25 (22.8–27.2)	0.19	0.11	24.9 (22.3–27)	25 (23.7–27.4)	0.07	0.22
Reduced LVEF	22 (18)	552 (34)	<0.01	0.36	22 (18)	23 (19)	1.00	0.02
Diabetes	8 (7)	146 (9)	0.46	0.09	8 (7)	13 (11)	0.33	0.14
Hypertension	49 (41)	686 (42)	0.83	0.03	49 (41)	49 (41)	1.00	<0.01
Smoking history			0.61	0.10			0.27	0.18
Never smoker	60 (50)	846 (52)			60 (50)	67 (56)		
Previous smoker	52 (43)	638 (39)			52 (43)	42 (35)		
Active smoker	8 (7)	138 (9)			8 (7)	11 (9)		

Characteristics	Unmatched analysis				Matched analysis			
	Trainees (*n* = 120)	Consultants (*n* = 1622)	*P*-value	SMD	Trainees (*n* = 120)	Consultants (*n* = 120)	*P*-value	SMD
Previous MI	9 (8)	224 (14)	0.07	0.21	9 (8)	14 (12)	0.40	0.14
Previous PCI	1 (1)	75 (5)	0.08	0.24	1 (1)	7 (6)	0.07	0.28
EuroSCORE	6 (4–7)	6 (4–8)	0.20	0.18	6 (4–7)	6 (4–7)	0.93	0.08
Preoperative AF	53 (44)	581 (36)	0.08	0.17	53 (44)	49 (41)	0.68	0.07
NYHA Class			0.22	0.21			0.37	0.12
Class I	10 (8)	183 (11)			8 (7)	8 (6)		
Class II	43 (36)	527 (33)			43 (36)	39 (33)		
Class III	57 (48)	689 (43)			57 (48)	60 (50)		
Class IV	10 (8)	223 (14)			10 (8)	13 (11)		
CCS class			0.53	0.2			0.14	0.28
0	91 (76)	1167 (72)			91 (76)	91 (76)		

Characteristics	Unmatched analysis				Matched analysis			
	Trainees (*n* = 120)	Consultants (*n* = 1622)	*P*-value	SMD	Trainees (*n* = 120)	Consultants (*n* = 120)	*P*-value	SMD
I	11 (9)	158 (10)			11 (9)	13 (11)		
II	13 (11)	156 (10)			13 (11)	6 (5)		
III	3 (2)	88 (5)			3 (2)	7 (6)		
IV	2 (2)	53 (3)			2 (2)	3 (2)		
Reoperative surgery	11 (9)	213 (13)	0.27	0.17	11 (9)	11 (9)	1.00	<0.01
Type of MV disease			<0.01	0.49			0.71	0.07
Stenosis	21 (18)	125 (8)			21 (18)	23 (19)		
Regurgitation	73 (62)	1264 (83)			73 (62)	71 (59)		
Mixed	23 (20)	135 (9)			23 (20)	24 (20)		
Not available	3 (2)	87 (5)			3 (2)	23 (19)		
Urgency			0.10	0.28			0.70	0.09
Elective	92 (77)	1097 (68)			92 (77)	94 (78)		

Characteristics	Unmatched analysis				Matched analysis			
	Trainees (*n* = 120)	Consultants (*n* = 1622)	*P*-value	SMD	Trainees (*n* = 120)	Consultants (*n* = 120)	*P*-value	SMD
Urgent	27 (22)	449 (28)			27 (23)	24 (20)		
Emergent	1 (1)	69 (4)			1 (1)	2 (2)		
Salvage	0 (0)	7 (0.4)			0 (0)	0 (0)		
Aetiology			<0.01	0.62			0.85	0.25
Congenital	4 (3)	72 (4)			4 (3)	9 (7)		
Degenerative	53 (44)	772 (48)			53 (44)	53 (44)		
Endocarditis	5 (4)	165 (10)			5 (4)	2 (2)		
Functional	0 (0)	13 (1)			0 (0)	0 (0)		
Ischaemic	5 (4)	142 (9)			5 (4)	4 (3)		
Rheumatic	44 (37)	223 (14)			44 (37)	45 (37)		
Other	3 (2)	99 (6)			3 (2)	3 (2)		

Characteristics	Unmatched analysis				Matched analysis			
	Trainees (*n* = 120)	Consultants (*n* = 1622)	*P*-value	SMD	Trainees (*n* = 120)	Consultants (*n* = 120)	*P*-value	SMD
Not available	6 (5)	124 (8)			6 (5)	4 (3)		

Data are expressed as median (IQR) for numerical variables and as *n* (%) for categorical variables.

AF: atrial fibrillation; BMI: body mass index; CCS: Canadian Cardiovascular Society; IQR: interquartile range; LVEF: left ventricular ejection fraction; MI: myocardial infarction; MV: mitral valve; NYHA: New York Heart Association; PCI: percutaneous coronary intervention; SMD: standardized mean difference.

Table 2. Operative outcomes

Characteristics	Unmatched analysis				Matched analysis			
	Trainees (n = 120)	**Consultants (n = 1622)**	***P*-value**	**SMD**	**Trainees (n = 120)**	**Consultants (n = 120)**	***P*-value**	**SMD**
Type of surgery			0.11	0.16			0.44	0.10
Repair	47 (39)	764 (47)			47 (39)	79 (66)		
Replacement	73 (61)	856 (53)			73 (61)	41 (44)		
Concomitant procedures	28 (23)	466 (29)	0.24	0.12	28 (23)	30 (25)	0.87	0.04
CPB time (min)	121 (93.2–146.3)	121 (97–153)	0.27	0.23	121 (93.3–146.3)	114.5 (94.8–149.3)	0.53	0.12
Cross-clamp time (min)	85 (70–105.3)	84 (67–106)	0.47	0.03	85 (70–105.3)	80 (63.8–107)	0.52	0.02
In-hospital mortality	2 (2)	98 (6)	0.04	0.23	2 (2)	7 (6)	0.18	0.22
New dialysis	1 (1)	57 (4)	0.18	0.18	1 (1)	5 (4)	0.10	0.21
CVA	2 (2)	23 (1)	1.00	0.01	2 (2)	3 (2)	1.00	0.06

Characteristics	Unmatched analysis				Matched analysis			
	Trainees (n = 120)	**Consultants (n = 1622)**	***P*-value**	**SMD**	**Trainees (n = 120)**	**Consultants (n = 120)**	***P*-value**	**SMD**
Reoperation for bleeding	7 (6)	88 (5)	1.00	0.02	7 (6)	5 (4)	0.77	0.07
Hospital length of stay (days)	9 (7–13)	9 (7–14)	0.43	0.06	9 (7–13)	9 (7–13)	0.61	0.10

Data are expressed as median (IQR) for numerical variables and *n* (%) for categorical variables.

CPB: cardiopulmonary bypass; CVA: cerebrovascular accident; IQR: interquartile range; SMD: standardized mean difference.

Figure Legend

Figure 1: The Kaplan–Meier survival for the overall cohort of patients undergoing mitral valve surgery.

Figure 2: The Kaplan–Meier survival for patients undergoing mitral valve surgery after propensity match.